

EPA Region 5 Records Ctr.



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TURTLES

of the United States and Canada

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Emydoidea blandingii (Holbrook, 1838)

Blanding's turtle

PLATE 27

*Emydoidea blandingii*Plastron of *Emydoidea blandingii*

RECOGNITION: This northern turtle has an elongated, smooth carapace (to 27.4 cm) that is neither keeled nor serrated. The broad first vertebral touches four marginals. The carapace is black, and each scute commonly has tan to yellow irregular spots or slightly radiating lines, but some individuals are patternless or their spots are faded to the point of being almost invisible. A movable hinge lies between the pectoral and abdominal scutes on the plastron. The plastron is connected to the carapace by ligaments; it has no plastral buttresses. It varies from yellow with a large, dark blotch at the outer, posterior corner of each major scute to almost totally black. The flattened head is moderate in size with a nonprotruding snout, a notched upper jaw, and protruding eyes. The top and sides of the head are blue-gray with tan reticulations, and the chin, throat, and neck are bright yellow. The upper jaw may be marked with dark bars. The triturating surfaces of the jaws are narrow and ridgeless. Other skin is blue-gray; some yellow scales occur on the tail and legs. The neck is very long, and the feet are webbed.

Males have dark pigmentation in their upper jaws, the cloacal vent behind the posterior rim of the carapace, and a slightly concave plastron. Females have yellow upper jaws, the cloacal vent under the posterior marginals, and flat plastra. Females also have longer plastra and higher carapaces than males (Rowe, 1992).

KARYOTYPE: The diploid chromosome number is 50: 20 metacentric or submetacentric, 10 subtelocentric, and 20 acrocentric or telocentric chromosomes (Stock, 1972).

FOSSIL RECORD: A late Pliocene (Blancan) fossil of a Blanding's turtle has been found in Kansas (Preston and McCoy, 1971; McCoy, 1973); Pleistocene remains are known from the Irvingtonian of

Kansas and Oklahoma (Taylor, 1943; Preston and McCoy, 1971; Holman, 1986a), and the Rancholabrean of Kansas, Mississippi, Missouri, and Ontario (Preston and McCoy, 1971; Jackson and Kaye, 1974a, 1975; Churcher et al., 1990). A 5,000-year-old postglacial fossil was discovered in Michigan (Holman, 1990), and archeological records exist for Illinois, Maine, New York, and Ontario (Bleakney, 1958a; Adler, 1968; Preston and McCoy, 1971; French, 1986). The Rancholabrean fossils from Jones Spring, Hickory County, Missouri, reported to be *Emydoidea blandingii* by Van Devender and King (1975) have been reidentified as *Terrapene carolina putnami* by Moodie and Van Devender (1977), and fossils of *Emys cwenzei* Taylor, 1943, from Kansas are now considered *E. blandingii* (Preston and McCoy, 1971; McCoy, 1973).

A Miocene (Barstovian) hypoplastron from an *Emydoidea* seems ancestral to *E. blandingii* (Hutchinson, 1981).

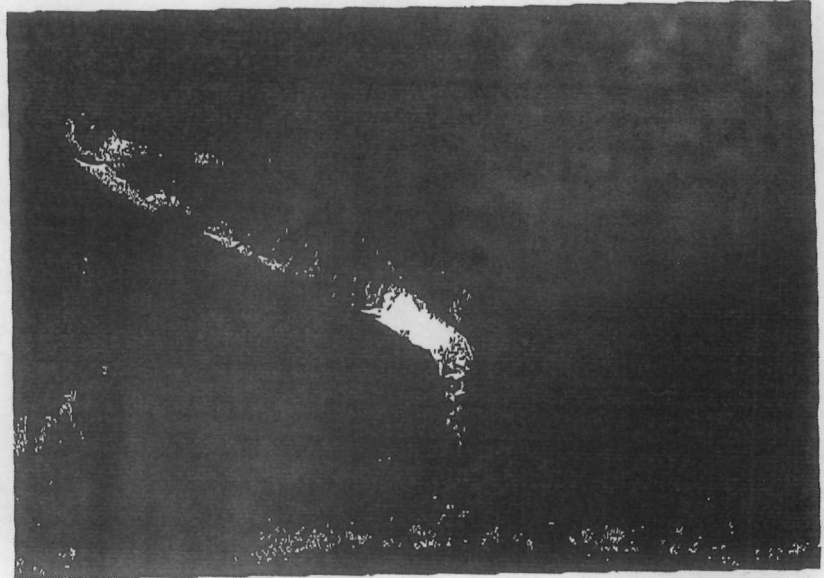
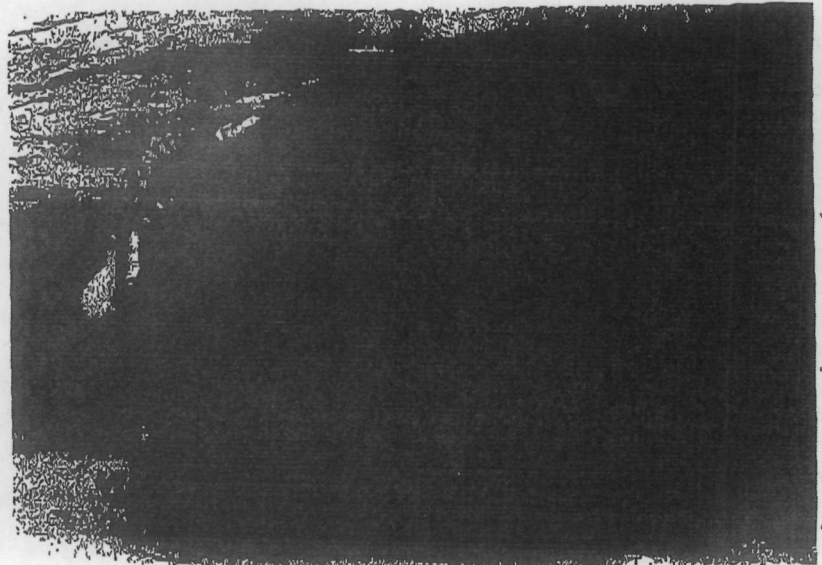
DISTRIBUTION: The main range of *Emydoidea* is from southwestern Quebec and southern Ontario south through the Great Lakes region, and west to Iowa, northeastern Missouri, southeastern South Dakota, and west-central Nebraska. It also occurs in scattered localities in southeastern New York, eastern Massachusetts, southern New Hampshire and adjacent Maine, and on Nova Scotia (Graham et al., 1987). Blanding's turtles occasionally cross Lake Erie to northwestern Pennsylvania (Ernst, 1985c).

GEOGRAPHIC VARIATION: No subspecies are recognized.

CONFUSING SPECIES: Box turtles of the genus *Terrapene* have a well-developed plastral hinge, but none have a yellow throat and chin, or, com-

monly, a notched carapace. Turtles with a hinge, and *C. s. carapace* with a st

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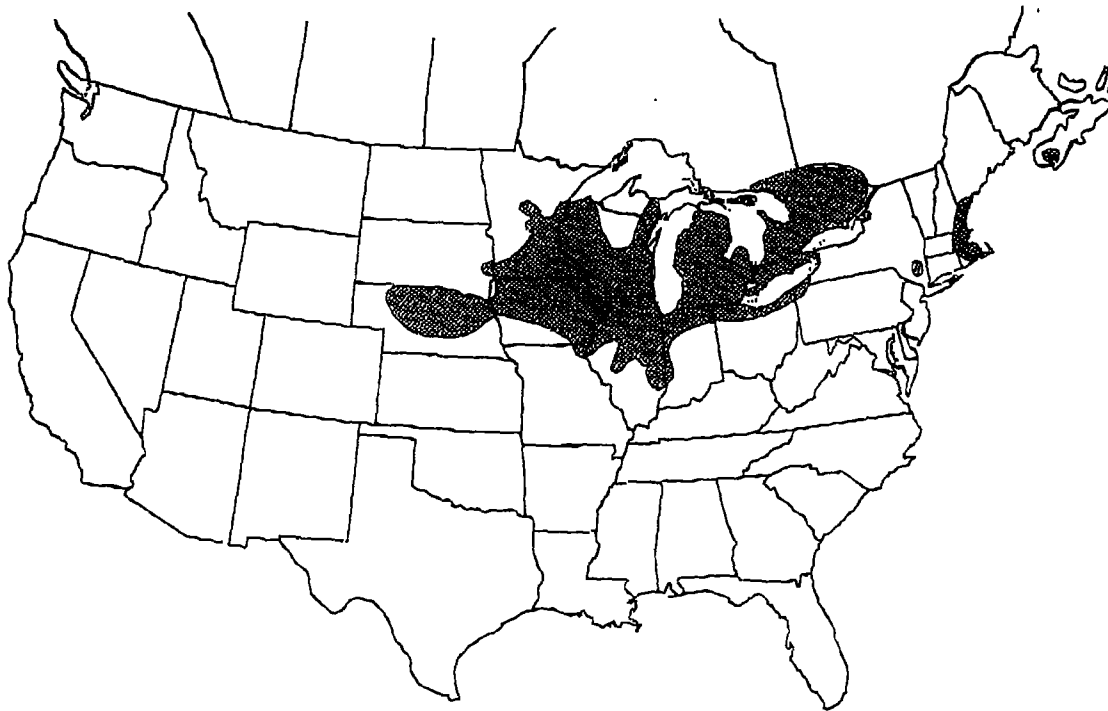
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monly, a notched upper jaw; *T. carolina* has a keeled carapace. Turtles of the genus *Clemmys* lack a plastral hinge, and *C. insculpta* has a sculptured, keeled carapace with a strongly serrated posterior rim.

HABITAT: In general, *Emydoides blandingii* lives in productive, eutrophic habitats, with clean shallow water, a soft but firm, organic bottom, and abundant aquatic vegetation. It is found in lakes, ponds, marshes, creeks, wet prairies, and sloughs.

Ross and Anderson (1990) noted that *Emydoides* in Wisconsin seem to spend most of the time in marshes, rather than ponds; but marshes are used less than expected based on habitat availability, as are also terrestrial habitats, and ponds with sand bottoms and no aquatic vegetation are rarely used. Wetlands covered by cattail (*Typha*) mats are not used either, but areas cleared of cattails by muskrats (*Ondatra zibethica*) are entered by the turtle, possibly for foraging. Habitat preferences may vary seasonally; in

242 *Emydoidea blandingii*Distribution of *Emydoidea blandingii*

early summer, marsh habitat is used in proportion to availability, but terrestrial and stream/ditch habitat use exceeds availability (Ross and Anderson, 1990; Rowe and Moll, 1991). Habitat in Wisconsin is characterized by high dissolved oxygen and high nitrogen and phosphorus concentrations, but not correlated with either water color or biochemical oxygen demand (Ross and Anderson, 1990).

In Minnesota, small juveniles primarily use emergent sedge (*Carex comosa*) habitats and alder (*Alnus rugosa*) hummocks (Pappas and Brecke, 1992). Other larger juvenile *Emydoidea* use sedge/water interfaces, and the largest juveniles are found in open water. As with adults, significant seasonal differences occur in the use of these various habitats.

BEHAVIOR: *Emydoidea* is primarily active during daylight. Under experimental conditions, at a 14:10-hour light:dark cycle and 25°C, its daily activity patterns are bimodal with peaks at about 0700 and 1600. At 15°C, activity tends to be unimodal with a peak at about noon (Graham, 1979b).

From May to August in northeastern Illinois, most activity begins between 0600 and 0800 and ends

between 1900 and 2200. The turtles are more active in the morning than at any other time. At night, they sleep suspended in aquatic vegetation or on pond bottoms beneath aquatic vegetation (Rowe and Moll, 1991).

Activity begins as early as April in Michigan and Missouri and lasts until September (Gibbons, 1968d; Kofron and Schreiber, 1985). In northeastern Illinois, Blanding's turtles are first seen in late March when water temperatures climb to 19°C, but data based on radiotelemetry indicate that some may be active at temperatures as low as 10°C (Rowe and Moll, 1991). They respond to baited traps from May through August. Rowe and Moll (1991) captured none in March, April, September, or October; the numbers captured per trap day in various months were: May, 0.095; June, 0.216; July, 0.055; August, 0.140. Most *Emydoidea* were trapped either in the morning or in the evening.

Hutchison et al. (1966) found the mean critical thermal maximum of 12 *Emydoidea* to be 39.5°C (38.2–40.6). This is one of the lowest maxima among the 25 species they examined, and probably is a reason for the species restriction to northern latitudes.

Several studies have shown that Blanding's turtles


may travel considerable distances in Wisconsin wetlands (mean, 396; Range, 10–1000 m). Movements of female turtles are generally greater than those of males because of postnatal dispersal. In contrast, only 1% of female movements were greater than 1 km (Ross and Anderson, 1989a).

Wisconsin *Emydoidea blandingii* are separated, active, and spend at least five days per year in water. The location of activity centers is related to the size of the core area studied by Ross (1989) and is significantly different from those of other species. Activity centers (Centers of female activity) (mean overlap 12.26%); activity centers are shared. Distance between activity centers of males (260 and 635 m) is greater than those of females (15 and 635 m). Shape was largely occupied.

Activity centers identified as clusters of activity. Activity centers (mean 0.6 ha), as in the summer (summer, 84.5% areas; all other areas, 100%); both range length and activity centers were significantly different between individuals occurring within 1 kilometer. Males per day than females (1991).

Several studies in Blanding's turtles have shown that females on land were seen on terrestrial movements in May and June between aquatic environments of up to 100 m. Take place as

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may travel considerable distances. Movements in a Wisconsin wetland complex ranged from 212 to 652 m (mean 396; Ross, 1989a). Minimum daily movements of females (mean 95 m) were significantly greater than those of males (mean 48 m), perhaps because of postnesting movements of females. Of female movements, 43% were over 100 m. In contrast, only 14% of male and 19% of juvenile female movements were greater than 100 m (Ross, 1989a).

Wisconsin *Emydoidea* have well-defined, widely separated, activity centers (areas in which individuals spend at least five days) (Ross and Anderson, 1990). The location of these centers changes over time, and the size of the centers of two males (0.57 and 0.94 ha) studied by Ross and Anderson did not differ significantly from those of adult females (mean 0.64 ha). Activity centers of juvenile females averaged 0.40 ha. Centers of females overlapped both those of males (mean overlap 12%) and other females (mean overlap 26%); activity centers of the two males were not shared. Distances between activity centers for two males (260 and 635 m) did not differ significantly from those of six females (mean 489 m), nor did the range lengths within activity centers between males (15 and 635 m) and females (mean 159 m). Center shape was largely determined by that of the wetland occupied.

Activity centers in an Illinois population were identified as clusters of relocations within an area of overall activity. Individuals occupied two to four activity centers ranging in size from 0.1 to 1.2 ha (mean 0.6 ha), and totaling 0.4–2.3 ha (mean 1.3 ha) in the summer (Rowe and Moll, 1991). During the summer, 84.5% of all activity was confined to these areas; all other activity was transient movement between or away from the centers. As in Wisconsin, both range length and total center area did not differ significantly between the sexes. Daily movements in activity centers were 1–230 m and peaked in July, but individuals occasionally made trips of up to one kilometer. Males moved significantly greater distances per day than females, except in May (Rowe and Moll, 1991).

Several studies have reported terrestrial tendencies in Blanding's turtles. Gibbons (1968d) found nesting females on land in Michigan in June, but both sexes were seen on land in April and September. Most terrestrial movement in an Illinois population occurs in May and June when both sexes periodically move between aquatic habitats. Long-distance displacements of up to 1.4 km at a rate of up to 550 m/day take place as males move between aquatic habitats.

Female trips are shorter and associated with nesting. From 18 to 29 May some Illinois *Emydoidea* moved inland 2–21 m under a variety of weather conditions and rested in leaf litter or vegetation for up to six hours (Rowe and Moll, 1991).

Some Wisconsin Blanding's turtles estivated for 0.5–5 days between late July and late August when air temperatures were 18–33°C. One turtle estivated repeatedly beneath herbaceous growth on land, and two others rested, partly buried, in the silt at the bottom of a creek under 30 cm of matted cattails. Aquatic estivation occurred in July and August at maximum air temperatures of 27–37.5°C (Ross and Anderson, 1990).

Blanding's turtle is fond of basking and has been seen sunning itself on muskrat lodges, steep banks of dikes and ditches, stumps, logs, piles of driftwood, sedge clumps, and cattail debris, both singly and with several other *Emydoidea* or with *Chrysemys picta*. The earliest spring sighting of this species in Nova Scotia was of one basking on 30 April (Dobson, 1971). Atmospheric basking occurs infrequently from late March to late August in Illinois. The turtles bask from 0758 to 1729, at air temperatures of 15–27°C, under sunny to partly cloudy conditions (Rowe and Moll, 1991). Juveniles in Minnesota bask on sedge (*Carex amosa*) tussocks and the roots of alder (*Alnus rugosa*), or perch on the branches of alders 20–90 cm above the water. When disturbed, these juveniles often crawl into holes or burrows at the base of the sedge tussocks (Pappas and Brocke, 1992).

Most Blanding's turtles enter overwintering sites between September and late November, depending on location, when water temperatures are 6–13°C (Kofron and Schreiber, 1985; Ross and Anderson, 1990; Rowe and Moll, 1991). In Wisconsin, hibernacula include the deepest parts of ponds and creeks with organic substrates. Dormant turtles lie partially buried in the substrate at mean water depths of 0.9 m, and several may hibernate within 10 m of each other. Hibernacula are not far from summer habitats, and five of six individuals found by Ross and Anderson (1990) hibernated within a summer activity center. At the Toledo Zoo, two spent the winter under wet leaves on land, but most hibernated successfully beneath masses of soggy leaves in their pool (Conant, 1951a).

Blanding's turtles do not immediately become dormant in winter. Evermann and Clark (1916) saw them swimming slowly beneath the ice in November in northern Indiana. Two Missouri *Emydoidea* overwintered in the mud among roots of grasses and shrubs in the shallow part of a marsh where water

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depth was 9.5–21 cm and maximum mud depth, 15 cm. Both made frequent movements of up to 1.3 m, but when the water temperature dropped to 2–3°C, they moved only 1–2 m (Kofron and Schreiber, 1985).

REPRODUCTION: The sexual cycles of *Emydoidea* are poorly known. That of the male has not been studied. Michigan females ovulate in May; a female collected in April contained numerous follicles 7 mm in diameter, but no eggs or enlarged follicles (Gibbons, 1968d). The urogenital morphology of both sexes is described in detail by Nicholson and Risley (1942).

Size and age at attainment of sexual maturity varies among populations and individuals of *Emydoidea*. Data collected during a 24-year study of Blanding's turtles in Michigan (Congdon and van Loben Sels, in press) provide the only information on maturation of the species. The youngest female found in its first mature season (primiparous) was 14 years old, 18.3 cm in plastron length, and 19.2 cm in carapace length, but 59% of all reproductive females in the population were smaller. The smallest sexually mature female (15.7-cm plastron, 16.3-cm carapace) was also one of the oldest at 20 years. The largest primiparous female (21.0-cm plastron, 22.5-cm carapace) was 18 years old. Primiparous females were 14–20 years of age, with 15.7–21.0 cm plastra and 16.3–21.5 cm carapaces. No relationship was detected between body size and age at first oviposition.

Other studies have determined the timing and size at maturation based on the age and size of reproducing females or the appearance of secondary sexual characteristics. Females in Wisconsin appear to mature at a plastron length of about 17 cm and at a minimum age of 18 years (Ross, 1989a). Graham and Doyle (1977) suspected that male Blanding's turtles in Massachusetts matured at plastron lengths of 18–19 cm in the 12th year of growth, based on the appearance of secondary sexual characteristics. Secondary sexual characters become evident in Missouri at plastron lengths of between 17 and 18 cm (Kofron and Schreiber, 1985).

Courtship and mating have been observed in every month from March to November, but are most common from March to July (Conant, 1951a; Graham and Doyle, 1979; Vogt, 1981a). The mating in Illinois on 17 November reported by P. W. Smith (1961) was surely a belated one, because these turtles are less active at that time of the year.

Courtship behavior, under seminatural conditions, was documented by Baker and Gillingham (1983),

and involves eight different male behaviors: (1) chase—pursuit of the female, often in contact with her posterior carapace; (2) mount—climbing onto the female's carapace; (3) gulping—drawing water into the mouth and expelling it from mouth or nostrils over the female's snout; (4) chinning—placement of the chin on the female's snout and exerting a downward or inward pressure; (5) chin-rubbing—lateral movement of the head while the chin or gular region is in contact with the female's snout; (6) swaying—horizontal movement of the head and neck without contacting the female's snout, and with neck extended and head bent downward at a sharp angle; (7) violent swaying—rapid horizontal swinging of the head and neck, arched in such a way as to allow the head to pass under the female's plastron, sometimes producing audible sounds when the male's plastron rubbed on the female's carapace; and (8) snorkel—at termination of a behavior, the male remained motionless, and then slowly raised his neck to the surface to breathe.

The courtships observed by Baker and Gillingham (1983) took place in water and from 20 April to 28 May at water temperatures of 7–21°C. A typical courtship sequence begins when a male approaches a female, climbs onto her carapace, and clasps her marginal scutes with his claws. If she moves away, he chases her. Once mounted, the male begins chinning for up to 70 minutes (mean 4), but stops if either turtle surfaces to breathe. Breathing periods last 7–22 seconds (mean 12) and males breathe significantly more often than females. Chin-rubbing usually follows a male snorkel behavior or female breathing attempt. If the female moves forward while mounted, the male ceases chinning and begins to gulp. Gulping bouts include 16–37 pulsations (mean 22) and individual gulps last about one or two seconds (mean 1.3). Gulping may be associated with the behavior observed by Graham and Doyle (1979) in which Massachusetts males expelled bubbles while mounted. Swaying usually follows gulping. A complete swaying sequence lasts one to three seconds (mean 1.2). If the female retracts her head at this stage the male resumes chinning her, but if she remains motionless, swaying changes to violent swaying, especially when the female retracts her head, limbs, and tail. Copulation occurs only when the female extends her tail. Each cycle of violent swaying lasts 0.27–0.66 sec (mean 0.33), and often causes the male to lose his grip on the female and fall off.

Intromission occurs only after swaying behavior. The male slides his tail beneath hers and inserts his penis as their tails touch. The male then releases his

grip on the female and 16.5–29.3 min (mean 16.5) before mounting another male.

The order of the behaviors is not random. The sequence is initiated early in the season, followed by the chin-rubbing behavior. There appears to be a sequence of gulping to swaying to dismounting is also observed (Baker and Gillingham, 1983).

The nesting season depends on geographic locations (Bleakney, 1991; and Moll, 1991; Rowe, 1992). In Michigan, nesting began on 9 June, and lasted through July (Congdon et al., 1991). A significant correlation between nesting temperatures and dates between 26 May and 1991. Seventeen females in Rowe (1992) were nesting in July; of these, nine from June to 3 July but were presumably successful in Massachusetts, the nesting season began in June (Linck et al., 1991).

Nesting is usually initiated in the early morning by 2300, and complete Massachusetts nesting was reported by Linck et al. (1991) entered a cornfield almost touched the ground, sweeping with her head at 180° and began digging. She rested for 10 minutes after the first egg was laid in intervals of about 10 minutes and 11 to move the egg. The final egg was laid 10 minutes after the first egg was laid. The nest was completed in the nest site by 1900 and "kneading" process of rocking the egg for minutes, and was covered with soil from the nest. The female faced the water v

le behaviors: (1) en in contact with nt—climbing onto g—drawing water t from mouth or ; (4) chinning— female's snout and pressure; (5) chin- he head while the t with the female's movement of the ; the female's snout, bent downward at a ;—rapid horizontal rched in such a way under the female's audible sounds when ie female's carapace; of a behavior, the nen slowly raised his

grip on the female and tilts backward. Mating may last 16.5–29.3 min (mean 23.0). If a male accidentally mounts another male the duration is short (<60 sec).

The order of the various male courtship behaviors is not random. The mount-chase interaction is important early in the sequence, snorkeling is frequently followed by the chin-rub and eventually chinning, and there appears to be a linear sequence from chinning to gulping to swaying and then violent swaying. Finally, dismounting is also associated with violent swaying (Baker and Gillingham, 1983).

The nesting season lasts from late May to early July, depending on geographic location and weather conditions (Bleakney, 1963; Congdon et al., 1983b; Rowe and Moll, 1991; Rowe, 1992). During six years in Michigan, nesting activity began between 23 May and 9 June, and lasted from 16 to 30 days (mean 23) (Congdon et al., 1983b). The onset of nesting was significantly correlated with April, but not May, temperatures. Females from northeastern Illinois nest between 26 May and 22 June (Rowe and Moll, 1991). Seventeen females from Nebraska collected by Rowe (1992) were gravid between 11 June and 10 July; of these, nine were collected on land from 19 June to 3 July between 1700 and 1900, when they were presumably searching for a nest site. In Massachusetts, the nesting season covers the first 24 days in June (Linck et al., 1989).

Nesting is usually completed at night, although it is initiated in the early evening. Most nests are completed by 2300, but some females finish later. A complete Massachusetts nesting sequence was reported by Linck et al. (1989). At 1920 the female entered a cornfield. She lowered her head until it almost touched the ground and made several alternating sweeps with her front legs. At 1933 she turned 180° and began digging the nest with alternating hind feet. She rested for intervals of up to a minute. The first egg was laid at 2049 and 10 more followed at intervals of about one minute each. She paused for about two minutes between deposition of eggs 10 and 11 to move the eggs in the chamber with her hind feet. The final egg was deposited at 2102 followed by 10 minutes of egg manipulation with the hind feet. At 2115 she began to fill the nest cavity, a process that was completed in five minutes. She then smoothed the nest site by rocking her plastron over the cavity and "kneading" the soil with her knuckles. The process of rocking and kneading lasted for about 90 minutes, and was interrupted by occasional sweeping of soil from the area around the cavity. Most Massachusetts females observed by Linck et al. (1989) faced the water while digging the nest.

The nest is flask shaped and about 18 cm deep; the opening is 7.5–10.0 cm in diameter, and the egg chamber is about 18 cm wide.

In Michigan the nesting process lasts about 2.5 hours once the site is selected (however, Snyder, 1921, observed a nesting sequence that took only 45 minutes to complete), and some females may remain on land for two to seven days (mean 4.5) to complete nesting (Congdon et al., 1983b). Females in Illinois may move overland for 5–17 days before nesting 650–900 m (mean 815) from their home ponds (Rowe and Moll, 1991). In Wisconsin, mean distance of the nest from the nearest water is 168 m (Ross and Anderson, 1990). During periods of prolonged terrestrial activity, females seek cover in dense vegetation or under leaf litter when not searching for a nest site or excavating.

Eight of 11 Michigan females observed nesting in more than one year showed nest site fidelity, but other females nested up to 1.3 km from previous nest sites (Congdon et al., 1983b). Nests were dug from 2 m to over 1 km from the nearest water (mean 135 m). Most females nest in areas adjacent to marshes where they are not considered to be residents. There is no relationship between the size of nesting females and the day of the nesting season they oviposit (Congdon et al., 1983b).

Most nests in Wisconsin are located in grasslands larger than six hectares and characterized by well-drained, sandy loam soil or sand (Ross and Anderson, 1990). Cover in this microhabitat is composed of 50.6% grasses and sedges, 25.5% other herbaceous plants, 23.9% bare soil, and very few woody species. Nests are located, on average, 18.4 m from shrubs, 36.3 m from trees, and 246 m from nonnesting activity centers.

Only a single clutch is deposited each year, but not all sexually mature females nest in a given year. On average, only 48% of the sexually mature Michigan females lay eggs in one year (Congdon et al., 1983b). Clutch size ranges from 3 to 22 eggs, but averages between 10 and 15 eggs (Rowe, 1992; Congdon and van Loben Sels, in press). The ellipsoidal, dull-white, hard-shelled eggs have a nodular surface and are 28.0–40.7 mm long, 17.7–26.0 mm wide, and weigh 8.9–15.8 g. The eggshell is 9.6% of egg weight and is composed of 45.2% fibrous layers and 54.8% mineral layers (Bleakney, 1963; Ewert, 1979a; Graham and Doyle, 1979; Brewster, 1982; Graham and Forsberg, 1986; DePari et al., 1987; MacCulloch and Weller, 1988; Congdon et al., 1983b; Congdon and van Loben Sels, 1991, in press; Rowe, 1992). Some of the data on egg dimensions are based on measure-

aker and Gillingham from 20 April to 28 7–21°C. A typical a male approaches a ace, and clasps her f she moves away, he male begins chinning), but stops if either ing periods last 7–22 breathe significantly -rubbing usually fol- or female breathing ward while mounted, gins to gulp. Gulping ons (mean 22) and or two seconds (mean ed with the behavior yle () in which bles while mounted. : A complete swaying nds (mean 1.2). If the rage the male resumes s motionless, swaying especially when the , and tail. Copulation xtends her tail. Each 0.27–0.66 sec (mean to lose his grip on the

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ments of x-radiographs and may result in 6.4–15.4% overestimations of actual size (Graham and Petokas, 1989; Congdon and van Loben Sels, 1991).

Clutch size in Michigan varies significantly among individuals and among years, although body size (carapace and plastron length) of reproductive females does not (Congdon et al., 1983b; Congdon and van Loben Sels, 1991, in press). Clutch size is positively correlated with female carapace length, but body size does not account for much of the variation in egg dimensions. Clutch size is not correlated with female age. It does not differ significantly between females with a mean age of 21 years and those with a mean minimum age of 47 years, nor between first-year breeders and veteran nesters. Females at least 55 years old reproduce more often (mean 0.57 clutches/year) than those 20–30 years old (mean 0.35 clutches/year). Clutch wet mass is 60.4–183.4 g (mean 111.7) and is also positively correlated with female length. The mean ratio of clutch wet mass to female wet mass is only 0.12. Mean clutch egg width, measured from x-radiographs, is positively correlated with clutch size. DePari et al. (1987) found no significant relationship between clutch size and female length in Massachusetts females ranging from 20.0 to 22.0 cm, but MacCulloch and Weller (1988) showed that both clutch mass and relative clutch mass are related significantly to both female mass and length in Ontario, and that clutch size is also related to female shell length, but that mean egg mass is not related to either clutch size or female length. However, in Nebraska, no measure of reproductive output is significantly related to female carapace length (Rowe, 1992).

The eggs of *Emydoides blandingii* have a relatively small lipid fraction, perhaps because the species does not usually overwinter in the nest (Gibbons and Nelson, 1978; Congdon et al., 1983b). Eggs contain 12.5–18.6% (mean 15.56) lipid by total weight; egg lipid weight is 0.45–0.63 g (mean 0.55), and the lean component dry weight ranges from 2.64 to 3.50 g (mean 3.0). Approximately 38% of the egg lipid stores are utilized by the embryo during development (Congdon et al., 1983b).

Incubation time varies as a function of temperature. Incubation time in the laboratory at various temperatures is as follows: 24°C, 81.6 days; 25–25.5°C, 71.3 days; 25–30°C, 52.4 days; 29.5–30°C, 49.3 days; and above 30°C, 47.4 days (Ewert, 1979a). In Michigan, hatchlings emerge from the middle of August to early October; the time between laying and emergence is 73–104 days (mean 84). Emergence usually occurs between 1000 and 1500 and may take

one to eight days. An average of 2.2 eggs per nest fail to develop, and in some years, all nests have some inviable eggs (Congdon et al., 1983b). Hatchlings hide almost immediately after emergence from the nest (David M. Carroll, pers. comm.).

Eggs were incubated under hydric conditions eliciting different patterns of net water exchange between eggs and air and substrate by G. C. Packard et al. (1982). Those incubated on wet and intermediate substrates increased in weight during the first half of incubation, but became lighter during the second half until their mass just before hatching was slightly lower than at oviposition. Eggs incubated on dry substrates and on platforms above substrates lost weight throughout incubation, with a rate of decline greater in the second half of incubation. Hatchling size was related to the amount of moisture in the environment in which its egg was incubated, and, possibly, to the net flux of water across the eggshell. Variation in hatchling size was not as great as has been reported for other turtles with flexible-shelled eggs, possibly owing to the constraints on water exchange imposed by the more complex shells of *Emydoides* eggs.

In the laboratory, the proportion of Blanding's turtle eggs that hatch is affected by the incubation temperature (Gutzke and Packard, 1987). Hatching success is greatest (95.2%) when eggs are incubated at 26.5°C, and slightly, but significantly, decreased (77.3%) when they are incubated at 31.0°C. No embryos develop in eggs incubated at 22°C.

The rounded, keeled carapace of the hatchling is dark brown to black, sometimes with spots, and is 29.0–38.8 mm long. The plastron has a large, black, central blotch on each scute, and the future hinge is suggested by a crease. The plastron is 25–35 mm long. The tail is proportionately much longer than that of adults. Hatchlings weigh 6–13 g (Graham and Doyle, 1979; Congdon and van Loben Sels, 1991). They constitute 66.2% of egg weight (Ewert, 1979a), and their body dry mass averages 14.7% lipid (Congdon et al., 1983b). Mean dry weight of hatchling lean and lipid components is 1.78 g and 0.31 g, respectively (Congdon et al., 1983b). The initial mass of the egg significantly affects the hatching mass of the young (Gutzke and Packard, 1987).

Sex determination in *Emydoides* is temperature dependent. Eggs incubated at 22.5–26.5°C produce 97–100% males, and eggs incubated at 30–31°C produce only females (Gutzke and Packard, 1987; Ewert and Nelson, 1991).

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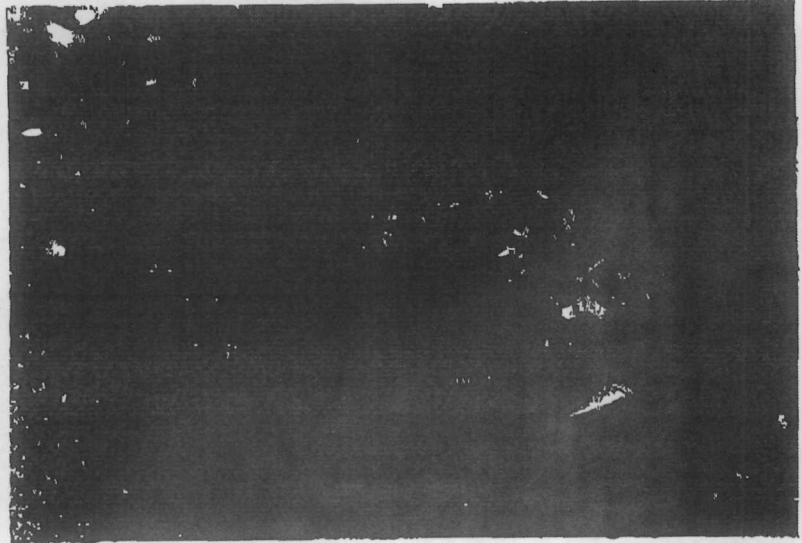
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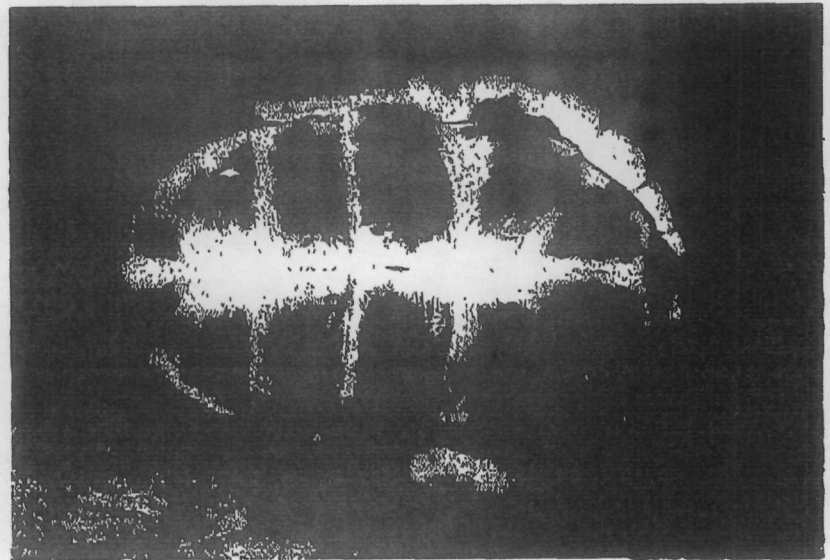
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Juvenile *Emydoidea blandingii*



Plastron of juvenile
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the effect of temperature on the development of *Emydoidea* poses two questions regarding the distribution of the species. First, how does it maintain a limited northern range when its embryos cannot complete development at low temperatures? Second, why, inasmuch as it is omnivorous, semiaquatic, capable of long overland migrations, and has eggs that are tolerant of dry conditions (G. C. Packard et al., 1982) and relatively high temperatures, has it not extended its range southward? Gutzke and Packard believe the answer to the first question is that,

apparently, females simply avoid nesting in cool woodland or shaded sites. They believe the answer to the second, more interesting, question is related to influences other than those of the environment on eggs and hatchlings. One possibility is that *Emydoidea* is excluded from the South through competition with other established emydids.

GROWTH AND LONGEVITY: Growth in Michigan Blanding's turtles is essentially linear until age 13, and averages about 10.4 mm and 75.3 g

248 *Emydoidea blandingii*

(between age 4 and 13) per year. Growth rates decline sharply between the ages of 16 and 18 at about 20.0 cm carapace length and a weight of 1.2 kg. Some, but not all, females grow indeterminately after age 20. Those that do grow have yearly increases ranging from 0.1 to 1.9 mm (mean 0.66) (Congdon and van Loben Sels, 1991). In Wisconsin, growth is 85.9% in the first year of life and declines until year eight when scute annuli are indiscernible (Ross, 1989a). Similar, but somewhat slower, growth rates occur in Massachusetts (Graham and Doyle, 1977). Blanding's turtles from Nebraska show an approximately 70% lengthening of the abdominal scute during their first year, but growth declines rapidly after this and becomes more constant at 4–9% about the fourth year (Rowe, 1992).

Congdon and van Loben Sels (in press) concluded that differences in juvenile growth rate and age of maturity, but not indeterminate growth, are responsible for most of the variation observed in the size of adult females. Individual growth rates of juveniles are significantly and negatively related to the age at which females mature; individuals that grow rapidly as juveniles mature at younger ages than individuals that grow slowly. Body size differences between fast- and slow-growing females are not related to age at sexual maturity inasmuch as both groups mature at similar sizes.

Blanding's turtles are capable of living well beyond 25 years (Gibbons, 1987; Congdon and van Loben Sels, in press). An individual was collected in Minnesota in 1988 inscribed with initials dated 1926. The condition of the initials was such that they were likely carved when the specimen was mature (older than 15 years). Thus, the turtle probably had a minimum reproductive period of 56 years and a minimum age of 77 years (Brecke and Moriarty, 1989), the oldest individual ever reported from a natural population.

FOOD HABITS: Feeding in Missouri begins in early April approximately two weeks after water temperatures reach and remain at 18°C. Feeding continues through June, ceases by mid-July, and resumes again when water temperatures fall to 21°C. The feeding period lasts only about 4.5 months. Crayfish are the dominant prey, but insects (Odonata, Trichoptera, Coleoptera, Diptera, Orthoptera), fish (*Lepomis cyanellus*) and their eggs, frogs (*Rana catesbeiana*), and plant material (filamentous algae and duckweed) are also ingested (Kofron and Schreiber, 1985). Lagler (1943) observed that crustaceans make up more than 50% of the food volume of Michigan *Emydoidea*, with insects providing another 25% of the

volume, and fish, other vertebrates, snails, leeches, and plants the remainder. Crayfish constituted 78% prey frequency and 58% volume in 92 Blanding's turtles examined by Penn (1950). Blanding's turtles in Massachusetts eat pondweed (*Potamogeton*), seeds, golden shiners (*Notemigonus crysoleucas*), and brown bullheads (*Ictalurus nebulosus*) (Graham and Doyle, 1977).

Cahn (1937) noted that this species eats leaves, grasses, berries, and other succulent vegetation, slugs, grubs, insect larvae, and earthworms on land, and insect larvae, crayfish, minnows, tadpoles, and frogs in water. Harding (1989) reported that Blanding's turtle will occasionally grab prey on land and then drag it into the water, and that no swallowing is done on land; however, Ernst and Barbour (1972) had captives eat dog food from a dry dish. Juveniles are very aggressive aquatic feeders (Harding, 1989).

Although prey may be captured by rapid thrusts of the long neck, and *Emydoidea* sometimes waits in small pools to ambush prey such as tadpoles (Ross, 1987), the main feeding strategy probably involves an entirely different behavior (Bramble, 1973). Blanding's turtle uses a pharyngeal mechanism that exploits the relatively high density and viscosity of water. Function of this mechanism relies chiefly on the generation of large negative pressures within the buccopharyngeal cavity through the rapid expansion of the chamber by the hyoid apparatus; coupled with fast inertial feeding thrusts of the head, such negative pressures quickly draw water and prey into the mouth. Lingual movements play little or no role in feeding. Morphological adaptations of this mechanism include a massive hyoid apparatus, small tongue, broad, flat palate, nonserrated or ridged jaws, and no appreciable cranial flexure.

PREDATORS AND DEFENSE: Of the turtles collected in Missouri by Kofron and Schreiber (1985), 31% had injuries or were missing body parts. Thirteen had injuries to the feet, eleven had damaged shells (cracks or chips), and five had lost part of their tails. Injuries were distributed evenly among adult males, adult females, and subadults. Like many turtles, *Emydoidea* are frequently killed on roads by cars (Kofron and Schreiber, 1985; Harding, 1990).

Blanding's turtle nests are frequently destroyed by predators. Nests located near the edges of habitats (ecotones) are more often plundered than are those dug more than 60 m from such edges (Temple, 1987). Nest predation in Michigan ranged from 42 to 93%. The most common predators were raccoons (*Procyon lotor*) and foxes (*Urocyon*, *Vulpes*); one nest was destroyed by ants. Following oviposition, 47% of

nests were destroyed five days, and 12% by the 30th day no nests were preyed. Observed nests that were significantly farther from open areas were more frequently than

All 16 nests found in Wisconsin were destroyed within 10 days of being located within 100 m of a water body (Temple, 1987). Nine skunks (*Mephitis mephitis*) and one mink (*Neogale vison*) were found near Wisconsin (Temple, 1987).

The color pattern of floating leaves of duckweed is a dominant feature in many wetlands of the turtle. This provides an advantage to the turtle in avoiding predation (Ross and Temple, 1987).

When handled, the turtle closes its shells and holds them tightly as possible. It does not attempt to bite. It pulls its head into its shell on the first disturbance. Defenders (Hayes, 1989).

POPULATIONS: Estimates for Michigan range from 1 to 10 turtles per hectare, with biomass and energy density the same hectare area (Congdon et al., 1991).

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nests were destroyed in the first 24 hours, 84% within five days, and 12% between days 6 and 30, but after the 30th day no nests observed were attacked. Some nests were preyed upon as hatchlings emerged. Observed nests that survived predation were not significantly farther from water than those attacked. Nests in open areas such as fields were preyed upon more frequently than nests in areas where a predator's search pattern was linear (Congdon et al., 1983b).

All 16 nests found by Ross and Anderson (1990) in Wisconsin were destroyed by predators. Ten of these were located within 50 m of a habitat edge (see Temple, 1987). Nine of the nests were destroyed by skunks (*Mephitis mephitis*), but raccoons and opossums (*Didelphis marsupialis*) also are egg predators in Wisconsin (Temple, 1987).

The color pattern of *Emydoidea* seems to imitate the floating leaves of duckweed (*Lemna*), which is abundant in many wetland habitats throughout the range of the turtle. This cryptic pattern may confer an advantage to the turtle by reducing vulnerability to predation (Ross and Lovich, 1992).

When handled, these turtles withdraw into their shells and close the movable lobes of the plastron as tightly as possible. They are timid and usually make no attempt to bite. Those touched on the ground may pull into their shells or tilt the shell in the direction of the disturbance. Defensive postures are discussed by Hayes (1989).

POPULATIONS: Blanding's turtle density estimates for Michigan range from 8.8 to 10.0 individuals per hectare, with a biomass of 7.9–8.8 kg/ha. Biomass and energy equivalents for eggs produced in the same hectare are 1.11 kg and 7,908 kilojoules (Congdon et al., 1986; Congdon and Gibbons,

1989). Density and biomass in Wisconsin are greater, 27.5 individuals per hectare and 45 kg/ha (Ross and Anderson, 1990). Blanding's turtle densities from various other localities are as follows: Missouri, 55/ha (Kofron and Schreiber, 1985); Massachusetts, 6.3/ha (Graham and Doyle, 1977); and Michigan, 15.8/ha (Gibbons, 1968d).

Sex ratios of Blanding's turtle populations range from essentially 1:1 to strongly female biased (Ross, 1989a; Gibbons, 1990b; Congdon and van Loben Sels, 1991). In Wisconsin, immatures represent 35% of one population, where the immature to adult ratio is 1.8:1 (Ross, 1989). Most studies have noted the rarity or absence of small Blanding's turtles in samples (Gibbons, 1968d; Kofron and Schreiber, 1985; Ross, 1989a; Congdon and van Loben Sels, 1991), but some researchers have managed to find large numbers (Pappas and Breckle, 1992). The size distributions of all Michigan males and females greater than 15.5-cm plastron length are not significantly different (Congdon and van Loben Sels, 1991).

The annualized survivorship of eggs and hatchlings in a Michigan population is only 18% (Congdon et al., 1983b; Iverson, 1991a).

REMARKS: Bramble (1974b) concluded that *Emydoidea* is most closely related to *Emys* and *Terrapene*, not *Desmognesi* as was previously believed. He based his conclusion on a shared plastron closing mechanism, other morphological similarities, and convergent feeding systems between *Desmognesi* and *Emydoidea*. This conclusion is strengthened by similar findings in an electrophoretic study of turtle myoglobins by Seidel and Adkins (1989).

Additional information on *Emydoidea* is summarized by McCoy (1973).

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